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Field Differences in External Funding: An Analysis of Funding Composition of Externally Funded Publications

Fredrik Niclas Piro[1], Henrik Karlstrøm[2], Ida Svege[3], Dag W. Aksnes[4]

[1]*fredrik.piro@nifu.no*, [2]*henrik.karlstrom@nifu.no*, [3]*ida.svege@nifu.no*, [4]*dag.w.aksnes@nifu.no*
NIFU – Nordic Institute for studies in Innovation, Research and Education, Økernveien 9, 0653 Oslo (Norway)

Abstract

The objective of this paper is to study field differences in external funding, using funding acknowledgment (FA) data from Web of Science for all papers with Norwegian authors in the years 2014-2022. Many studies use FA information as a dichotomous variable, but a large share of the FA information is institutional funding, and thus not external. To the best of our knowledge, we provide the first ever study of a large corpus of WoS publications where all FA information has been manually verified and standardized, and where institutional FA has been excluded. Our results indicate that using FA as a dichotomous variable overestimates the presence of external funding by 7.4 per cent. When only external funding is considered, we find that 58.9 per cent of all papers have external funding, and that this funding is highly unevenly spread across scientific fields. Furthermore, we find that external funding strongly increases the citation numbers of papers.

Introduction

In recent decades, there has been a steady growth in the magnitude of external funding of research globally (Tian et al., 2024; Heinze, 2008), i.e. shifting from institutional to project-based funding (Aagaard et al., 2021). Web of Science (WoS) allows for exploring this by using funding acknowledgements (FA) information. The purpose of this paper is to provide the first field comparison of external funding based on a large corpus of scientific publications, complementing previous funding studies in two ways. First, by clearly distinguishing between funding that is external and funding that is not, i.e. focusing only on external funding. This part of the analysis will provide a novel robustness check of the extent to which WoS funding acknowledgements data capture *external funding*. Second, by classifying all funding sources by type and country, thus exploring the roles of different funding types in different scientific fields. The analysis is based on all WoS publications in the period 2014-2022 with at least one Norwegian author: 259,198 papers with a total of 363,778 FAs listed.

Funding acknowledgments in Web of Science

The focus of this paper is on *publications*, and their funding (or lack thereof). The opportunity to analyze the presence of funding in WoS became possible in 2008 when FA data was introduced. Still, there are many caveats when using FA information. Once entered as FA in WoS, several functional challenges arise (Aagaard et al., 2021), of which most are attributed to the lack of standardization in how FA is reported. Most sources are listed by the funders' name (in the many ways it can be (mis-)spelled), whereas others are listed through project names (or

acronyms) or grant numbers. A major contribution from our study is the manual validation and standardization of all FA data listed in all publications. The FA text in WoS does not indicate what type of funding is provided[1], i.e. it does not differentiate between the two core types of funding, which is external funding and institutional funding (block funding). Hence, it is not possible to classify the large majority of reported FA by its many different funding types and purposes (El-Ouahi, 2024), i.e. whether it targets long-term or short-term projects (research or innovation), mobility, infrastructure, or being aimed towards particular groups of researchers, e.g. women or early-career researchers (Schweiger et al., 2024). The main difference between these two funding types is competition (by actively writing proposals or not), although this does come with some modifications as internal funding within an academic institution may be distributed following internal competition (Schweiger et al., 2024). Not all external funding, however, is based on competition (through submission of proposals to open calls). Foremost, industry funding (possibly also charity funding) may be channeled through researchers without competition and without a peer-review style assessment of proposals (Thelwall et al., 2023). We may also reason that much public funding from e.g. ministries may be provided from other types of processes than open calls.

Our operationalization of 'external funding' contrasts most of the literature on research funding which has either limited its focus to single programs (such as an excellence scheme or a specific call) or to more encompassing analyses based on 'everything' which is listed as FA. We believe such an approach is intertwined with the difficulty in distinguishing between 'funded' and 'unfunded' research (Thelwall et al., 2023), because a substantial part of WoS papers that do not recognize funding, are in fact funded by someone (in most cases, the researchers' institutions), whereas a substantial part of the 'funded' research, that is papers with FA are in fact listing institutional funding. We see 'external funding' as funding that is a) not institutional block funding, b) that is limited in time, and c) (mostly) obtained in open competition. This means that we are targeting funding that is channeled within a principal-agency framework (Gläser & Velarde, 2018), and with the funder of the research in a position to exercise influence on the content of the research carried out (Thelwall et al., 2023).

Several recent studies have used FA information either to compare funding across fields, or to classify FA data to show the engagement of different funding sources. For example, *Morillo* (2014) studied funding types (national/international) in papers from Spanish author addresses in four disciplines, revealing large differences across fields in the presence of FA and that international funding was associated with higher citation rates. In another Spanish study, *Alvarez-Bornstein, Diaz-Faes & Bordons* (2019) compared the funding patterns (public/private and national/international) of two medical fields. Here 89.9% of papers in virology had FA compared to 45% in Cardiac and Cardiovascular Systems. *El-Ouahi* (2024) studied publications with authors from the Middle East and North Africa (MENA), finding that about half of

[1] Infrequently, the FA text disclose types of funding, such as "project grant", "postdoc grant", "Professor Chair", "Endowment", "center of excellence funding", etc.

the papers had FA identical to the same organization as one of the authors, indicating institutional funding rather than external funding. *Diaz-Faes & Bordons* (2014) used FA as a dichotomous variable, but the results of this Spanish study are still relevant to us, because of its encompassing presentation of results across all fields in WoS. Here, FA was reported in two thirds of all papers, but with strong variations across fields. Tian et al. (2024) studied 13 million papers in WoS (2011-2020), with the aim of exploring changes in *universality* and *multiplicity* of funding over time. The former points to the presence of funding or not (a dichotomous approach), and the latter to the number of funders acknowledged. From 2011 to 2020 there was an increase in universality from 66.3% to 74.3%, and in multiplicity from 2.82 to 3.26 funders.

Data & methods

For this study, we applied a local version of WoS maintained by the Norwegian Agency for Shared Services in Education and Research. We retrieved 'Funding Agency' and 'Grant Number' fields in WoS, for all papers published in the years 2014-2022 with at least one Norwegian author. This dataset covers a total of 259,198 papers classified as original research papers, reviews and proceeding papers. All FA information has been manually read, interpreted (for example by internet searches) to identify the name, country and type of funding organization, as we are interested not only in whether there is a presence of external funding, but also in the *composition* of the funding. This requires a classification of *all* listed (external) funders. We have classified the funding organizations in the following categories: *Public sector* (which includes large programs such as the European Framework Programs for Research and Innovation), *Private sector* (which has been divided into three groups: pharmaceutical companies; companies operating within the oil and gas industry; other private companies), *Charity* (which includes non-governmental and non-profit foundations), *Other* (which includes organizations that do not have funding as their primary target, such as medical associations), and *Unknown*. The latter represents FA data that we at the time of writing (January 2025) have not yet correctly classified and currently present in 6.3 per cent of the papers, and thus a possible source of error. Nevertheless, we stress that our sample of FA is based on a correct classification of 93.7 per cent of all reported FA.

The sample of funders contain 1,756 unique Norwegian and 7,557 unique non-Norwegian funding sources. Considering the number of listed funding sources in the whole dataset we find 97,153 Norwegian funding acknowledgements and 266,625 non-Norwegian funding acknowledgements. Hence, in a study of Norwegian papers, only 26.7 per cent of the funding acknowledgements are Norwegian. The Research Council of Norway stands out as the most frequent single funding organization to papers with Norwegian authors (57,274 papers), followed by the European Framework Programs for Research and Innovation (EU FPs)[2] (20,125 papers), the Natural Science Foundation of China (NSFC) (5,351 papers), and the US agencies

[2] Please note that the second largest funding agency, the EU FPs is not equal to funding from the EU. It only points at the Framework Programs (FP6, FP7 and Horizon Europe), whereas other EU funding has been assigned other categories.

National Institutes of Health (NIH) (5,189 papers) and National Science Foundation (NSF) (4,437 papers). In comparing FA and external funding across scientific fields, we have grouped the papers based on their WoS journal categories into sixteen broad subject fields, following the classification suggested by NordForsk (2017). For papers in multidisciplinary journals and papers with missing information about journal categories, we have used the WoS macro, meso and micro topic classification scheme to discretionary regroup the papers to NordForsk's categories. Our study also includes a brief citation analysis. Here we calculated mean normalized citation scores (MNCS), where citation numbers are normalized by subject field, article type and year as well as a citation percentile indicator, identifying the top 10 percentile publications.

Results

In table 1 we show percentages of papers across subject fields that have reported FA, followed by percentages after exclusion of FA information that we consider to be institutional funding. At the overall level, we find that there is an overestimation of external funding equal to 7.4 per cent in the FA information in WoS. 63.9 per cent of the papers reported FA, but according to our classification, the percentage of papers with external funding is lower: 58.9 per cent. There are strong differences across subject fields in the presence of external funding. Fields from natural sciences are mostly above 70 per cent (exceptions being Engineering and Mathematics & Statistics at 57-58 per cent). Medical related fields show a gradient from Psychology (41.9%), Health sciences (51.9%), Clinical Medicine (59.6%) to Biomedicine & Molecular Biosciences (73.8%). Humanities (22.1%) and Social Sciences (37.2%) have the lowest shares.

Public funding sources account for the majority of FA and was reported in 53.3 per cent of all papers (Table 2), with the highest rates in Biology, Chemistry, Physics and Geosciences. In terms of being a complementary source of funding, charities are highly present in some of the subject fields where the public funding is lower than the overall percentage for public funding. This is foremost visible in Clinical medicine; Health sciences; and Psychology, where there are lower shares of papers with public funding, than for public funding overall.

Table 1. Percentage of papers reporting FA, and percentage of papers with external funding.

Subject field	Papers (n)	% with FA	% with external funding	% Overestimation
Agriculture. Fisheries & Forestry	9181	77.4	73.3	5.55
Biology	13285	80.6	77.1	4.44
Biomedicine & Molecular Biosciences	24562	78.1	73.8	5.78
Business Studies & Economics	8707	39.6	36.4	8.84
Chemistry	8257	80.0	75.4	6.07
Clinical medicine	35610	65.4	59.6	9.87

Computer & Information Science	12405	49.9	46.3	7.82
Engineering	34621	60.5	57.2	5.82
Geosciences	24104	77.9	74.8	4.21
Health sciences	19440	60.8	51.9	17.11
Humanities	8564	25.6	22.1	15.77
Materials science	6738	75.5	71.6	5.44
Mathematics & Statistics	4957	62.0	58.1	6.69
Physics	14209	77.0	74.4	3.43
Psychology	6823	49.2	41.9	17.37
Social sciences	27574	40.9	37.2	9.94
Total	259198	63.3	58.9	7.43

By contrast, here we find some of the most active involvement from charities: 28.6 per cent of papers in Clinical medicine; 16 per cent of papers in Health sciences and 10.5 per cent of papers in Psychology reported funding from charities. Nevertheless, the highest degree of funding from charities is reported in Biomedicine & Molecular Biosciences (28.7 per cent of the papers). Pharmaceutical companies were involved in 6.3 per cent of papers in Clinical medicine and 3.2 per cent of papers in Biomedicine & Molecular Biosciences; and oil/gas companies were involved in 5.2 per cent of papers in Geosciences and 4.1 per cent of papers in Engineering. Nevertheless, all three types of private funding display low percentages, i.e., they did not fund a large share of Norwegian papers.

Table 2. Percentage of papers with funding from key sources.

	Public	Charity	Private	Pharma	Oil	Other
Agriculture. Fisheries & Forestry	67.6	9.5	7.2	0.4	0.4	3.0
Biology	72.5	17.6	3.1	0.3	1.9	5.4
Biomedicine & Molecular Biosciences	67.0	28.7	3.1	3.2	0.6	3.3
Business Studies & Economics	33.0	3.7	0.7	0.1	0.3	0.6
Chemistry	72.5	9.3	4.3	0.3	2.7	1.8
Clinical medicine	45.7	28.6	3.4	6.3	0.1	3.4
Computer & Information Science	44.4	3.3	2.0	0.0	1.0	0.4
Engineering	53.9	2.7	4.8	0.1	4.1	1.1
Geosciences	70.4	8.8	2.6	0.1	5.2	3.5
Health sciences	42.3	16.0	2.5	1.0	0.1	3.2
Humanities	19.7	3.3	0.3	0.0	0.0	0.7
Materials science	68.7	5.8	6.2	0.0	1.8	0.9
Mathematics & Statistics	55.5	8.5	0.8	0.1	1.7	1.2
Physics	72.5	14.9	3.0	0.1	1.6	4.3
Psychology	36.5	10.5	0.7	0.3	0.1	2.1
Social sciences	34.2	3.9	0.7	0.0	0.3	1.1
Total	53.3	12.8	3.0	1.3	1.6	2.5

The different types of funders display different citation numbers across fields (not shown in tables). For example, for highly cited papers (within the top 10 per cent most cited from the same year and field), public funding varies from 8.1 per cent highly cited papers in Chemistry to 20.4 per cent in Clinical medicine. All funding types except the oil sector (9.6 per cent) have higher shares of highly cited papers than the world average (highest for Pharma and Charity; 28.8 and 19.9 per cent respectively). In table 3 we show differences in MNCS and highly cited papers for externally funded papers and papers without funding (which includes institutional FA). Presence of external funding is strongly associated with higher citation rates compared to papers without such funding (Table 3). On average externally funded papers have 45.3 per cent higher shares of highly cited papers and 35.5 per cent higher mean citation scores.

Table 3. Percentage of papers with funding from key sources.

	Per cent highly cited papers (10pctile)			MNCS (mean)		
	No funding	External funding	% diff.	No funding	External funding	% diff.
Agriculture. Fisheries & Forestry	10.2	13.5	32.7	1.10	1.38	25.6
Biology	11.8	14.8	25.8	1.11	1.40	25.5
Biomedicine & Molecular Biosciences	11.0	16.0	45.3	1.18	1.56	33.1
Business Studies & Economics	10.8	16.7	55.1	1.14	1.53	34.3
Chemistry	6.1	8.0	32.8	0.82	0.99	21.3
Clinical medicine	13.2	20.4	54.3	1.50	2.20	46.3
Computer & Information Science	10.3	13.7	33.0	1.04	1.36	30.3
Engineering	10.3	12.3	19.4	1.04	1.25	20.4
Geosciences	11.7	15.2	30.3	1.12	1.48	31.9
Health sciences	10.6	13.4	27.0	1.18	1.35	14.4
Humanities	9.7	22.1	28.0	1.12	2.27	102.3
Materials science	7.4	8.8	18.0	0.90	0.99	10.4
Mathematics & Statistics	7.6	11.5	51.4	0.89	1.26	42.0
Physics	9.1	13.3	46.1	0.97	1.45	49.5
Psychology	10.7	13.8	29.1	1.14	1.34	17.2
Social sciences	10.3	18.5	80.4	1.16	1.74	49.4
Total	10.7	15.6	45.3	1.18	1.59	35.5

The largest differences in citation indexes between funded and unfunded papers are seen in Humanities, which is a bit of special case due to this field's publishing and citation patterns. In other fields, compared to the total numbers, there is an especially strong effect of external funding in Social sciences; Clinical Medicine; Mathematics & Statistics; and in Physics (i.e. the difference in percentage between funded and unfunded papers are higher than the average for *both* highly cited papers

and MNCS). Note that in all fields, citation scores are higher for externally funded papers.

Discussion & conclusions

Our study has quantified the degree to which WoS FA data captures external funding and shown how such funding influence citation numbers across fields. We acknowledge that Norway is not representative to the world, given the high concentration of national funding through the Research Council of Norway, and with a much smaller representation of private foundations than for example in neighboring countries Sweden and Denmark. Still, the presence of international co-authorship, thus also international funding, is high in the papers we have studied. Being research in process, more work still needs to be done on the classification of (yet) *Unknown* FA sources. Later analysis will incorporate the aspect of *intensity* of funding and the interplay of different funding organizations (Tian et al., 2024), as for example EU publications display extremely high citation scores (Morillo, 2014). Nevertheless, the current analysis represents a novel contribution to the understanding of what WoS' FA data tells us, and how external research funding varies by field and how it is cited.

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